REMARKS

Amendments are submitted in response to the Office Action of January 14, 2004. Applicants respectfully request reconsideration of the present application in view of the amendments set forth above and the remarks below.

Applicants amend Claim 1 to recite setting a *maximum spot size* to be used to pattern the resist where a large exposure area will not impact a *critical region* of the pattern; setting a *minimum spot size* to be used to pattern at least one critical region; setting at least one *intermediate spot size* to be used in a *buffer region*; and varying the size of the radiation beam using the maximum spot size, the minimum spot size, and the at least one intermediate spot size. Support for this amendment can be found at p. 44, line 25 – p. 45, line 5, and throughout the specification and drawings.

Claim 6 has been amended to recite a *moving* spot, the spot moving a *defined scanning speed* and varying the spot size *without changing the scanning speed.* Support for this amendment can be found at p. 44, lines 6-20.

New independent claims 14 and 22 have also been added. Support for claim 14 and the claims that depend from it can be found in the original claims and at p. 44, line 25 – p. 45. line 5, as well as at page 41, lines 10-25; p. 45, lines 5-20; and throughout the specification and claims. Support for claim 22 and the claims depending therefrom can be found at p. 41, lines 10-25; p. 44, line 25 – p. 45, line 25; as well as throughout the specification and claims. No new matter has been added.

Double Patenting

The Examiner objected to claim 12 as conflicting with claim 19 of Application No. 09/022,974. Claim 12 has been cancelled by amendment.

Claim Rejections – 35 U.S.C. § 102

The Office Action rejects claims 1, 2, 4-8, and 11-13 pursuant to 35 U.S.C. 102(b) as being unpatentable over U.S. Patent No. 5,753,171 to Serbin et al. ("Serbin"). In particular, the Office Action states that Serbin discloses repeatedly depositing and patterning a resist layer and varying the beam spot size during the exposure, as well as, exposing the perimeter with a finer beam.

Applicant respectfully traverses this rejection.

The Invention

In conventional processes for building multi-layer resists, attempts have been made to reduce the time required to expose the layers of the resist. For example, where a large portion of a layer needs to be exposed, the radiation beam can trace a honeycomb pattern. Such partial patterning techniques are only useful in negative resist processes where exposure serves to solidify the exposed regions. While using such patterns reduces the required exposure time, the structural fortitude of the resulting part may be less than ideal.

Applicants have discovered a process for producing multilayered resists at faster speeds by modulating the laser beam spot size over a layer of a resist. The result is an expeditious patterning method which is useful with both positive and negative resists -- and does not compromise the structural integrity of multi-layer constructs. The method includes setting a maximum spot size for patterning the resist in an exposure area that will not impact a critical region of the pattern, setting a minimum spot size to be used in at least one critical region, and setting at least one intermediate spot size to be used in a buffer region. The method also includes varying the size of a radiation beam over at least one layer of a multi-layer resist using the maximum spot size, the minimum spot size, and at least one intermediate spot size.

In addition Applicants' methods account for the non-uniform intensity profiles of radiation beams (e.g., Gaussian or Airy disk distributions) typically used to expose resists. Such

nonuniform energy profiles deliver the highest energy intensity toward the center and a nonlinearly diminishing dose in the radial direction. Unfortunately, the radiation delivered at the periphery of a nonuniform radiation beam can overlap with radiation doses delivered to adjacent areas of the resist layer and create edge effects.

Edge effects can be particularly troublesome when multiple spot sizes are used. The critical region, the area near pattern edges and/or where depth needs to be controlled, requires a small, well defined spot to accurately pattern the resist. Large spots cannot be used too close to this region because the fringe regions of a large spot energy profile will overlap with the critical region and deliver an undesired additional dose of radiation to the critical region (e.g., a spill-over effect). As a result, the critical region will have poor definition and the quality of the resulting multilayered product will be diminished. In order to overcome this problem, the Applicants teach the use of a buffer region which lies between the critical region and the interior region.

Varying the spot size while also providing a buffer region allows a large spot to quickly pattern the interior region of a resist layer without delivering unwanted radiation to the critical region. Fewer passes of the beam are needed to expose the internal area, while a higher resolution spot size exposes the critical region. As a result, the multilayer resist can be exposed and built up more quickly.

Claim 1

The Serbin reference generally teaches exposing resists with a variable spot light beam. Serbin teaches that different foci, laser powers, and scanning speeds can be used in the different regions of the layer. (See Abstract)

Serbin, however, fails to appreciate the advantages (in terms of efficiency) of using a high scanning speed throughout the patterning process. Moreover Serbin fails to disclose the utility of a defined buffer region. Instead, Serbin merely discloses an outer envelope region 25 and an inner core region 26 to pattern a resist. As stated in column 4, lines 29-34 "the layer is irradiated with a smaller beam diameter or focus as indicated by the small circles in the envelope

region 25 (FIG. 3) and with a larger beam diameter or focus as indicated by the larger circles, in the core region 26." The Serbin reference fails to appreciate that by using a buffer region between the inner and outer regions, the spillover effects caused by the use of the larger and smaller beams can be controlled.

In FIG. 3 the Serbin reference shows a smaller spot size immediately adjacent to the large spot size with no explanation of how the energy profile of the larger beam interacts with the critical area along the edge of the exposure pattern. Serbin has no appreciation that most sources of lithographic radiation have nonuniform energy profiles which can cause spillover effects, affecting the exposure of the resist in the critical region.

In contrast, the Applicants teach the use of a *buffer region* between the critical region, which is exposed with a small spot size, and the interior region, which can be exposed with a large spot size. This buffer region can include additional passes with the small spot size and/or the use of an *intermediate spot size* used between the critical region and the interior region. Nowhere does Serbin disclose this concept.

Serbin thus fails to disclose varying the size of a radiation beam using a maximum spot size, a minimum spot size, and at least one intermediate spot size as required by claim 1, as amended.

Claim 6

Independent claim 6 comprises a method for patterning a multilayered resist including scanning a beam of radiation to form a *moving spot* on the first layer and thereby exposing a portion of the first layer of resist material to the moving spot at a *defined scanning speed.* The spot size of the radiation beam is varied without changing the scanning speed.

Scanning a resist layer with a varying spot size, while using a constant scanning velocity, quickly exposes the multilayered resist. Applicant has found that reducing scanning velocity increases the time required to scan the desired exposure pattern and therefore increases the total production time. Thus, claim 6 calls for a constant, and preferably maximum, scanning velocity

to expose at least one layer of the resist. Conversely, the Serbin reference teaches varying the scanning speed of the radiation beam such that the core region is scanned at a higher velocity than the envelope region. Sebin acknowledges that this change in scanning speed will increase production time (Col. 4, lines 35-39; Abstract). In contrast, Applicants have found that when the spot size is varied over a layer of the resist, a *constant scanning speed* is both desirable and more effective.

Accordingly, the Serbin reference does not anticipate claim 6, as amended.

<u>Claims 13</u>

Claim 13, as in claim 1, requires patterning a multilayered resist by repeatedly depositing layers and exposing portions of each layer to radiation. The size of the radiation beam is varied over at least one layer of the multilayered resist, wherein the interior of a layer is patterned at a larger spot size relative to perimeter portions which are patterned with *smaller sized spots* of radiation. Claim 13 requires *multiple sizes of spots* smaller than the larger spot used in the interior of the layer. As discussed above, Serbin fails to disclose the use of an intermediately sized spot of radiation and instead relies on a large and a small spot size.

<u>Claim 14</u>

New independent claim 14 requires *different* spot sizes in each of a *critical region*, a *buffer* region, and an *interior region.* Again, Serbin fails to disclose a buffer region. Instead, Serbin states that the envelope region uses a small spot size and the core region uses a large spot size. Nowhere does Serbin suggest or disclose the use of a buffer region.

<u>Claim 22</u>

Claim 22 is directed to a method of modulating exposure of a multi-layer resist using a beam of radiation having a *non-uniform lateral energy distribution.* The method includes establishing a *desired scanning speed* for a *moving spot* of radiation to expose a resist, determining a *maximum spot size* allowable for exposing regions of the pattern without reducing

the scanning speed, determining at *least one smaller spot size* needed to expose a *buffer region*, establishing a buffer region in which the smaller spot size will be employed to buffer a critical region, and patterning the resist while varying the spot size and using the smaller spot size to expose the buffer region.

Claim 22 requires a *buffer region* in which the smaller spot size is employed to buffer the critical region. As discussed above, the Serbin reference fails to disclose this concept. In addition, claim 22 includes a maximum spot size for exposing the resist such that the maximum spot size will not require reducing the scanning speed. For a given laser power, the spot size can only be enlarged so much without having to reduce scanning speed to account for diminished energy density. At this maximum spot size there is no additional benefit gained by further increasing the spot size. Nowhere does Serbin suggest or disclose choosing the maximum spot size based on the scanning velocity. Accordingly, Serbin fails to anticipate claim 22.

Claim Rejections – 35 U.S.C. § 103(a)

Claims 1, 3, and 6-11 are rejected pursuant to 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,496,683 to Asano in view of prior art admitted by Applicant. In particular, the Examiner state that Asano teaches predefining the pattern to be exposed in each layer of a multilayered resist pattern and repeated deposition and exposure of the resist layers. In addition, Asano allegedly teaches that varying the spot size during scanning exposure is known in the prior art (2; 46-49).

Applicant respectfully disagrees.

Again, it is noted that Applicants have discovered a process for producing multilayered resists at faster speeds by modulating the laser beam spot size over a layer of a resist. The result is an expeditious patterning method which can reduce or eliminate the need for short cuts such as exposing layers in a honeycomb pattern. The method includes setting a maximum spot size for patterning the resist in an exposures area that will not impact a critical region of the pattern, setting a minimum spot size to be used to pattern at least one critical region, and setting at least one intermediate spot size to be used in a buffer region. The method also includes varying the

size of a radiation beam over at least one layer of a multi-layer resist using the maximum spot size, the minimum spot size, and at least one intermediate spot size.

Asano generally relates to methods for developing photo-setting resin. In particular, a radiation beam is scanned along a contour line of a shaped region to set the shaped region (i.e., the beam is scanned along the perimeter). This first scan is preferably performed in a vector scanning mode. The exposure step is then completed by scanning the interior region with a radiation beam in raster scanning mode. This approach apparently allows Asano to improve photo-setting speed, but nowhere does Asano teach varying spot size.

Although Asano uses two scans, one on the contour line and one in the interior, there is no disclosure that the spot size is varied between the scans or during one of the scans. As stated by Asano, "Since the radiation beam moves along the contour line, the scanned set layer is shaped highly accurately along the contour line without having to reduce the spot diameter of the radiation beam and the scanning pitch." Asano uses the perimeter scan to improve accuracy, without having to vary spot size between the inner and outer portions of the resist layer.

The Examiner points to Col. 2, lines 46-49 as teaching varying spot size of a radiation beam during a scanning exposure. The cited passage states;

> To produce a three-dimensional resin model highly accurately according to the conventional optical shaping process, it is necessary to reduce the diameter of the ultraviolet laser beam spot and also to reduce the scanning pitch. However, reducing the spot diameter and the scanning pitch results in an increase in the time required to produce the resin model or requires stricter beam position control at the start-of-scan and end-of-scan points.

This passage, found in the Background of the Invention, only states that using a smaller spot size allows for a more accurate resin model. It does not say that the spot size is *varied* over different parts of the layer. Instead, this paragraph suggests that using a smaller spot size over the *whole* layer allows for increased accuracy. Unfortunately, the drawback of this approach is that scanning with a smaller spot size requires more time. The present invention overcomes this problem by varying the spot size over at least one layer of resist, a concept not found in Asano.

With respect to claims 3 and 8-11, the Examiner states that Asano does not teach using a positive resist, developing the resist, using a novolac resist and heating the resist, but argues that Applicant admits that these are known in the prior art. Applicants disagree, the specification does not contain any admission that these limitations are found in the prior art. Regardless, these claims are allowable at least because they depend from base claims that have been amended to clarify Applicants' contribution to the art.

Conclusion

Applicants submit that independent claims 1, 6, 13, 14, and 22 are patentably distinct from the prior art, and dependent claims 2-5, 7-11, 15-21, and 24-27 are allowable at least because they depend from allowable base claims. Allowance is therefore respectfully requested.

The Examiner is urged to telephone the undersigned Attorney for Applicants in the event that such communication is deemed to expedite allowance of this application.

Respectfully submitted,

Date: May 14, 2004

Thomas J. Engellenner
Reg. No. 28,711
Attorney for Applicant(s)

Nutter, McClennen & Fish, LLP
155 Seaport Blvd.
World Trade Center West
Boston, MA 02210-2604
Tel: (617) 439-2948
Fax: (617) 310-9948

1327154.1